LESSON 13
CONCRETING OPERATIONS

DRILLED SHAFT FOUNDATION INSPECTION

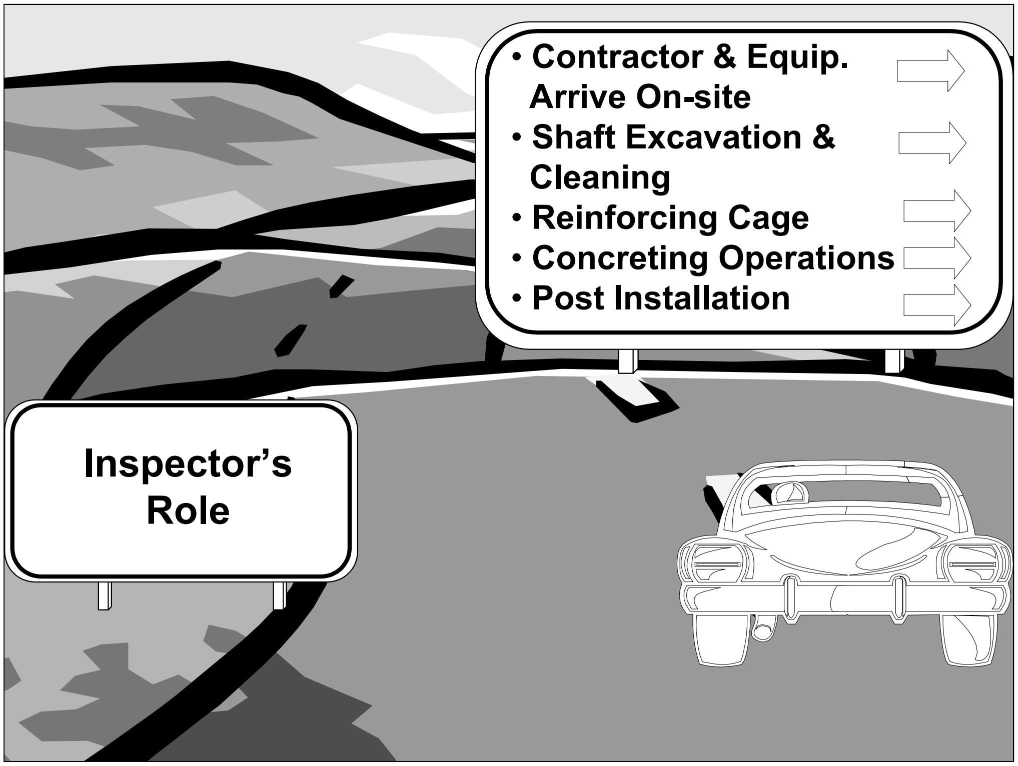
DECEMBER 2002

LESSON 13
CONCRETING OPERATIONS
NOTES

LESSON 13

CONCRETING OPERATIONS

13-3



• Contractor & Equip. Arrive On-site
• Shaft Excavation & Cleaning
• Reinforcing Cage
• Concreting Operations
• Post Installation
Inspector's Role

LEARNING OBJECTIVES

- Describe how to verify Checklist Questions 48-55
- Describe typical slump requirements for Drilled Shaft concrete
- Utilize the Concrete Placement Log inspection form to determine theoretical concrete volumes and placed concrete volume curves

13-5

INSPECTOR DUTIES

Concreting Operations

Responsible to:

- **Verify hole cleanliness**
- **Test concrete**
- **Monitor concrete volumes**
- **Prepare Concrete Placement Log**
- **Check Const. Tolerances**

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CONCRETE FOR DRILLED SHAFTS

Drilled Shaft Inspector

-vs-

Concrete Acceptance Inspector

13-7

Typically the Drilled Shaft Inspector is not in the position to be responsible for performing any required QC concrete testing. This is generally performed by a Inspector who has any required concrete qualifications, such as ACI Level I Field Technician.

There is more than enough for the Drilled Shaft Inspector to keep up with and remember, there is a time limit on the placement for the shaft. The Contractor can't be held up with the placement while you are off making cylinders, sampling trucks, etc.

CONCRETE FOR DRILLED SHAFTS

- **Typically Type I or Type II Portland Cement Concrete**
  - **Typical 28 day strength- 3500- 4000 psi (24.1- 27.6 MPa)**
- **Environmental Classification impacts mix design**
- **Generally, local specifications will dictate:**
  - **Types of concrete that can be used**
  - **Types by environments**

13-8

We want to have fluid concrete, yet we need to keep a low water - cement ratio in order to improve durability and strength. W/C = 0.45 is a good compromise between having a mix that has no water not needed for hydration (W/C of around 0.20) and a mix that is very fluid from water alone (W/C of around 0.60). Low-Range water reducers can be used to obtain good fluidity with that water-cement ratio. When the concrete can set quickly without warning, the contractor may not be able to complete all of the operations in time to produce an acceptable drilled shaft.

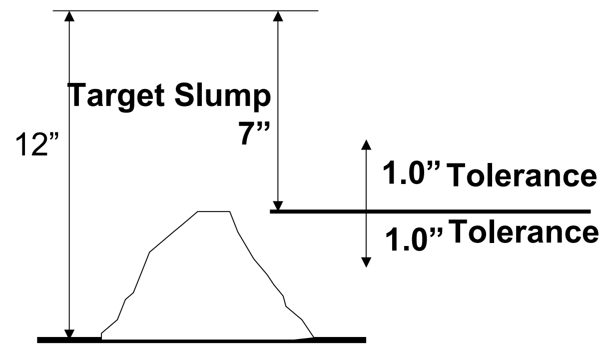
from FHWA Publication IF-99-025

Concrete for drilled shafts must be designed and placed in a manner that is unique to drilled shafts. Most drilled shafts have length-to-diameter ratios of 10 to 30 and have reinforcing steel cages. Many are constructed using either temporary casing or drilling slurry. Concrete for drilled shafts must therefore be designed and placed in such a manner that it can be pumped, be dropped or flow through a tremie by gravity to the bottom of the excavation; flow easily through the rebar cage without vibration (so that the concrete is not inadvertently mixed with drilling fluid, ground water or soil); displace drilling slurry or water while rising in a narrow borehole and in the annular space between the cage and the borehole wall; and will not segregate or become leached of cement paste in the process. Simultaneously, it must have the appropriate strength, stiffness and durability after it has cured.

The local specifications will dictate the Types of concrete that are to be used for drilled shafts.

DRILLED SHAFT CONCRETE TYPICAL SLUMP RANGE

All conditions except placement under drilling fluid



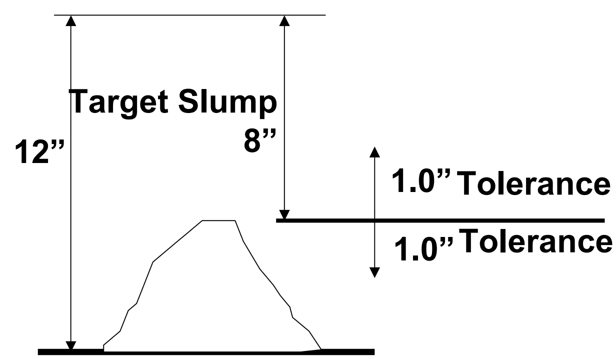
13-9

….Slump requirements are based on providing the necessary quality of workability for uniform and proper placement throughout the duration of shaft construction. The following table provides suggested slump values:

Slump Range	Typical Condition
7 in. ± 1in. 175 mm ± 25 mm	All conditions except placement under a drilling fluid
8 in. ± 1in. 200 mm ± 25 mm	Placement under a drilling fluid

DRILLED SHAFT CONCRETE TYPICAL SLUMP RANGE

Placement under drilling fluid



13-10

….Slump requirements are based on providing the necessary quality of orkability for uniform and proper placement throughout the duration of shaft construction. The following table provides suggested slump values:

Slump Range	Typical Condition
7 in. ± 1in. 175 mm ± 25 mm	All conditions except placement under a drilling fluid
8 in. ± 1in. 200 mm ± 25 mm	Placement under a drilling fluid

SLUMP OK FOR DRILLED SHAFTS

1

LOW SLUMP

Concrete that is plastic, but with slump too low for drilled shafts.

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HIGH SLUMP

Concrete with high slump, but poor consistency (is not plastic), as indicated by lumpy appearance (segregation).

13-13

SELF CONSOLIDATING CONCRETE

- Highly flowable
- No segregation
- Small aggregate

13-14

Photo courtesy of Grace Construction Products

Self Consolidating Concrete (SCC) is an advanced approach to the production of highly flowable, self-leveling concrete that can be placed without vibration equipment and without segregation.

Superplasticizers are added to the concrete mix to produce concrete with excellent workability and high early and ultimate strengths.

SELF CONSOLIDATING CONCRETE

- Requires Superplasticizers
- Higher content of Cementitious and filler materials
- Lower water/cementitious ratio

13-15

Photo courtesy of Grace Construction Products

Self Consolidating Concrete has some unique advantages:

-Self placement- the need for vibration can be eliminated because SCC is highly flowable concrete that will change shape under its own weight to self-level and self-consolidate.

- No segregation- SCC is a flowable yet highly cohesive material with no segregation and significantly reduced bleeding.

- No blocking- SCC can pass freely through narrow opening, such as closely spaced rebar for seismic resistance designed shafts, due to the small aggregate and therefore eliminates "blocking" behind obstructions and stopping the flow of concrete.

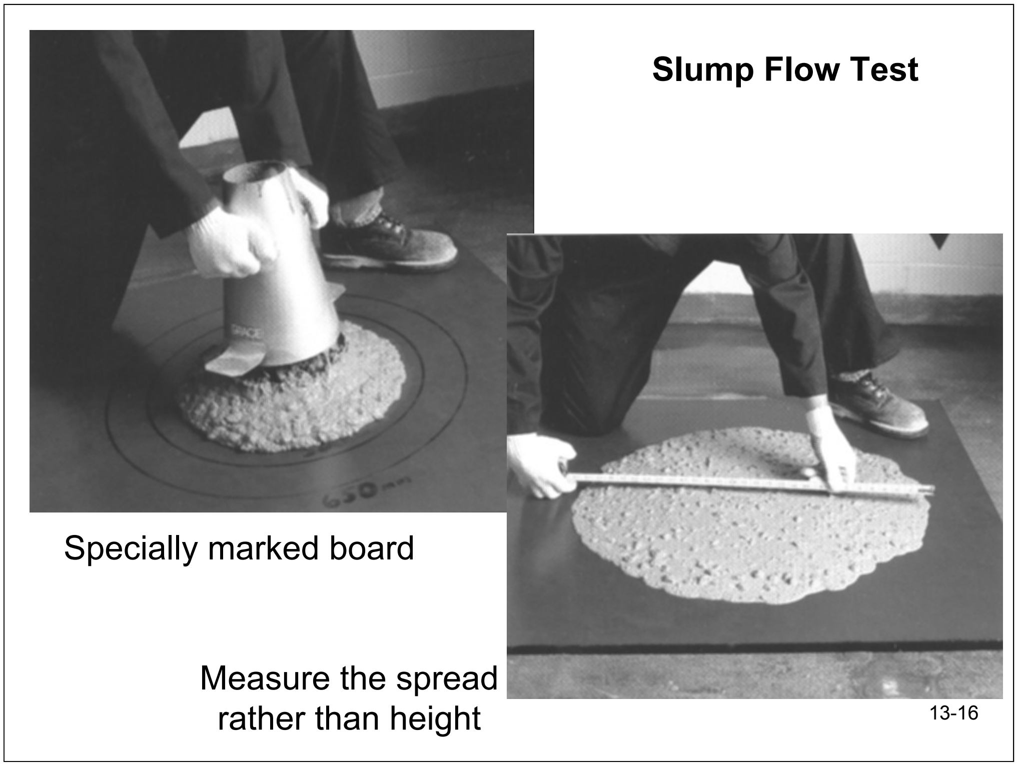
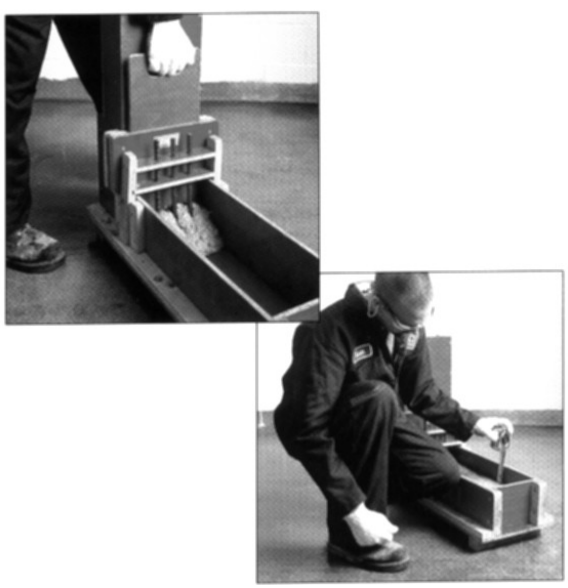


Photo courtesy of Grace Construction Products

Due to its high flowability, standard concrete tests are not appropriate for SCC.

A “Slump Flow Test” has been developed for use with SCC and it measures flow diameter and rate over time on a special measuring board. Typical slump flow diameter is between 24 to 32 inches (600 to 800 mm).

Other tests include the “L Box”, “U Box”, “J-Ring” and “V-funnel”. Below is a photograph of the “L Box” test measuring flow and blocking resistance of a mix.



LEARNING OBJECTIVE #2
Describe typical slump requirements for Drilled Shaft concrete

What is the typical range of 28 day strengths for drilled shaft concrete?

What is the target slump for drilled shaft concrete used under drilling fluids?

13-17

<u>LEARNING OBJECTIVE #2</u>
Describe typical slump requirements for Drilled Shaft concrete

Including the allowable tolerances, what is the range in slump for drilled shaft concrete?

What is the target slump for drilled shaft concrete used in all conditions except under drilling fluids?

13-18

SAMPLE DRILLED SHAFT INSPECTION CHECKLIST

Concreting Operations

48. Prior to concrete placement, has the slurry (both manufactured & natural) been tested in accordance with xxx.38, Slurry? 48 48
49. If required, was casing removed per xxx.36.1, Temporary Casings? 49 49
50. Was the discharge end of the tremie maintained in the concrete mass with proper concrete head above it xxx.61, Tremies)? 50 50
51. If free-fall placement (dry shaft only), was concrete placed in accordance with xxx.60, Concrete Placement? 51 51
52. Did the placement occur within the time limit specified (xxx.60, Concrete Placement)? 52 52
53. Are you filling out the concrete placement and volume forms? 53 53
54. When placing concrete, did the contractor overflow the shaft until good concrete flowed (xxx.60, Concrete Placement)? 54 54
55. Were concrete acceptance tests performed as required? 55 55

13-19

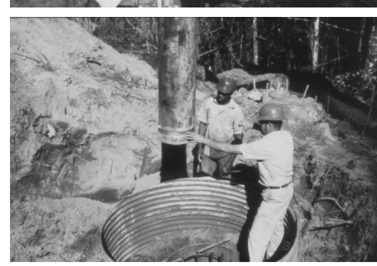
SAMPLE DRILLED SHAFT INSPECTOR'S CHECKLIST

The following is a general checklist to follow when constructing a Drilled Shaft. The answer to each of these should be "yes" unless plans, specifications or specific approval has been given otherwise ***CONSULT WITH RESPONSIBLE ENGINEER FOR YOUR SPECIFIC PROJECT RESPONSIBILITIES.***

	Yes	No	NA
Reinforcing Cage			
41. Is the rebar the correct size and configured in accordance with the project plans?	41	41	
42. Is the rebar properly tied in accordance with xxx.50, Reinforcing Steel Cage Construction & Placement?	42	42	
43. Does the Contractor have the proper spacers for the steel cage in accordance with xxx.50, Reinforcing Steel Cage Construction & Placement?	43	43	
44. Does the Contractor have the proper amount of spacers for the steel cage in accordance with xxx.50, Reinforcing Steel Cage Construction & Placement?	44	44	
45. If the cage is spliced, was it done in accordance with the contract documents?	45	45	
46. Is the steel cage secured from settling and from floating (during concrete placement cages sometimes rise with the concrete) (xxx.50, Reinforcing Steel Cage Construction & Placement)?	46	46	
47. Is the top of the steel cage at the proper elevation in accordance with xxx.41, Construction Tolerances?	47	47	
Concreting Operations			
48. Prior to concrete placement, has the slurry (both manufactured & natural) been tested in accordance with xxx.38, Slurry?	48	48	
49. If required, was casing removed per xxx.36.1, Temporary Casings?	49	49	
50. Was the discharge end of the tremie maintained in the concrete mass with proper concrete head above it xxx.61, Tremies)?	50	50	
51. If free-fall placement (dry shaft only), was concrete placed in accordance with xxx.60, Concrete Placement?	51	51	
52. Did the placement occur within the time limit specified (xxx.60, Concrete Placement)?	52	52	
53. Are you filling out the concrete placement and volume forms?	53	53	
54. When placing concrete, did the Contractor overflow the shaft until good concrete flowed (xxx.60, Concrete Placement)?	54	54	
55. Were concrete acceptance tests performed as required?	55	55	
Post Installation			
56. If shaft is constructed in open water, is the shaft protected for seven days or until the concrete strength reaches a minimum of 2,500 psi (17MPa) in accordance with xxx.36, Casings?	56	56	
57. Is all casing removed to the proper elevation in accordance with xxx.36.2, Permanent Casing?	57	57	
58. Has the Contractor complied with xxx. 64, Nondestructive Evaluation, if required?	58	58	
59. Is the shaft within the applicable construction tolerances (xxx. 41, Construction Tolerances)?	59	59	
60. Has the Drilled Shaft Log been completed?	60	60	
61. Have you documented the Pay Items?	61	61	
Notes/Comments			

CONCRETE PLACEMENT

Tremie Method

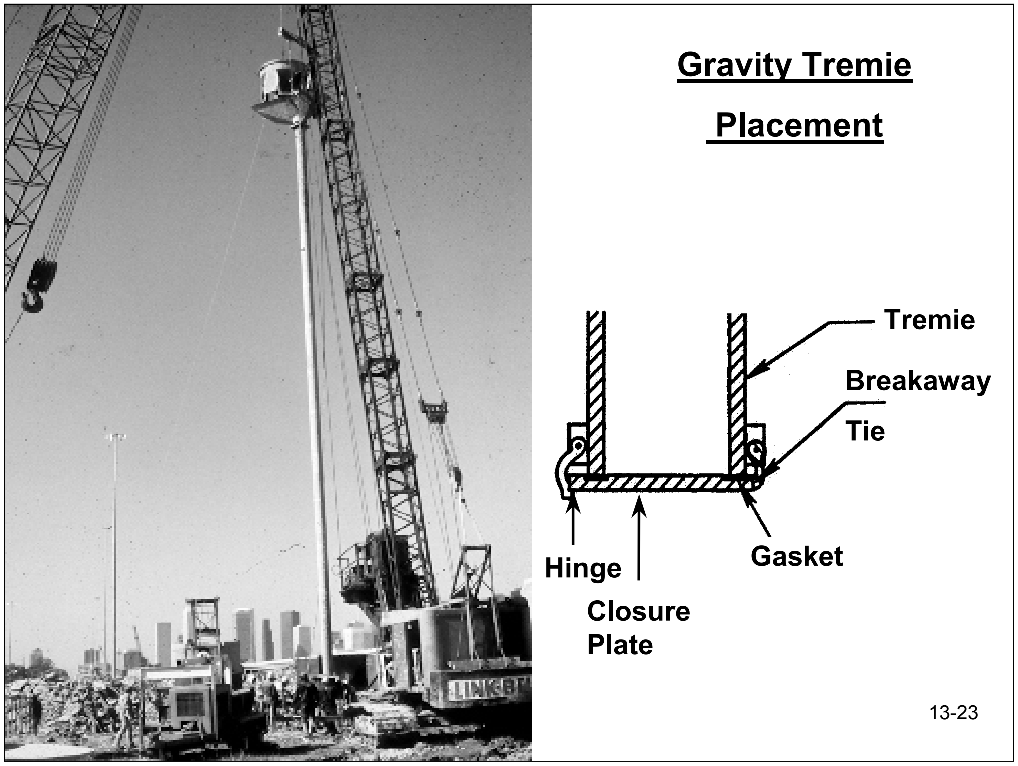


When the wet method is used, concrete will need to be placed either by a gravity-fed tremie, like the one shown on the right, above, or by a pump-line. Different contractors have different preferences. It is important that placement of concrete begin right at the bottom of the hole just as soon as possible after clean-out is finished so as to insert the fluid concrete beneath the water or slurry in the hole and push it out the top. This contractor chose to use a gravity-fed tremie because he believes that a better initial surge of fluid concrete, and therefore less entrapment of slurry or cuttings, can be achieved this way than with a pump. There is no scientific evidence to prove that this is true, however.

The tremie should be either a solid steel (not aluminum) tube or a jointed tube with watertight joints. It has an opening (orifice) at the bottom and is fed through a hopper on top of the tremie pipe with concrete supplied by buckets (shown here) or by a flexible pump line. Typical inside diameters are 10 to 12 inches. Larger diameters are occasionally used if more than one truck is depositing concrete into the tremie at the same time (as for deep, large-diameter shafts).

Pump Method

A concrete pump is frequently used to transport the concrete from a convenient discharge location for the ready-mix trucks to the gravity-fed tremie. Another frequent use of the concrete pump is to transport the concrete directly into the borehole.



A gravity-fed tremie is a steel tube, usually with a hopper on the top, that is fed from a pump or by discharging from a bucket. Aluminum should never be used because of reactions with concrete, and plastic pipe such as PVC should be discouraged because it is not robust enough.

The inside of the tremie needs to be smooth to allow the concrete to flow freely.

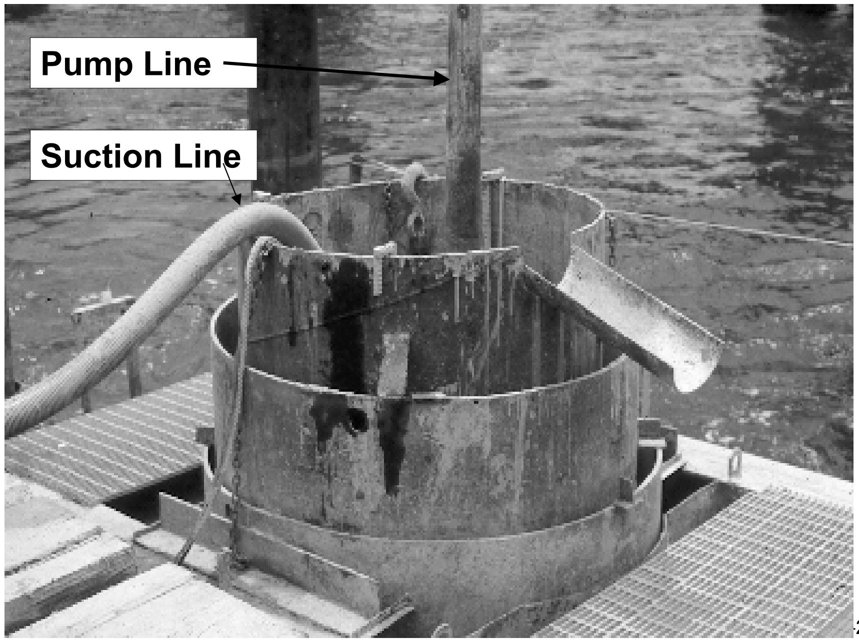
If placing concrete in water or slurry, the tremie must be deployed so as to minimize contamination to the concrete. The two most common methods are;

- Seal the bottom of the tremie with a some type of plate prior to insertion into the hole
- A plug may be inserted at the top of the tremie after it is inserted in the hole

Shown above is a typical hinged closure plate.

A more common seal consists of a steel plate held in place with "duct" tape with an additional layer of plastic to insure water tightness.

Pump Line Placement



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from FHWA Publication IF-99-025

Pump placement is similar to gravity tremie placement, except that the concrete is forcibly pumped down a solid steel tube (line) that is typically 5 to 6 inches in diameter. Smaller lines (down to 3 inches) are permissible if grout, rather than concrete, is used. Note that concrete with the same workability that is used for gravity tremie placement is used for pump placement, even though the concrete can be pumped with lesser workability. The high workability is needed to affect proper flow of the concrete once it is deposited in the borehole. Here, with this pour in deep water in an estuary, it is easier to move concrete around by pumping it from the trucks (which have been barged out to the bridge location) directly into the borehole. In order to aid in pumping long distances, air-entraining agents may be added to the concrete mix. Most of the air is lost in the pumping process. With pumped concrete it is just as important to keep the concrete and slurry or water separated from one another as it is with concrete placed by gravity tremie. This is usually done by placing a "pig" or plug in the top of the pump line and pumping it through the line with the pumped concrete. (Some contractors place it in the bottom, which is of no use if the plug is not watertight.) Note that the pig should be made of non-collapsing material that will also float to the top of the slurry once the concrete begins being expelled from the orifice. Some contractors will use a small amount of rich cement grout as the plug. Others may use slotted Styrofoam or similar material. As with the gravity tremie the pour always starts at the very bottom of the borehole, and the bottom orifice is always kept positioned well within the rising column of fluid concrete. A high-volume pump is essential for this operation.

Free Fall Method

13-25

from FHWA Publication IF-99-025

In the dry or casing methods, free-fall placement is quite acceptable. Experiments have been conducted with free-fall heights of up to 18 m (60 ft) without causing segregation in cohesive concrete with the attributes discussed earlier (e. g., maximum coarse aggregate size of 3/4 inch). If segregation is a concern of the designer, the maximum coarse aggregate size can be reduced to 1/4 to 3/8 inch. As shown here, it is important to direct the flow of the concrete to the middle of the cage, so that it does not fall through rebar, which may cause the concrete to segregate. If this cannot be done (small-diameter cage or large shaft aspect ratio), a partial-depth tremie pipe or elephant trunk (canvas tremie) may be needed. However, free fall should be allowed whenever possible in order to decrease concretes placement time and reduces costs.

When placed in this manner the concrete should not be vibrated, as vibration may promote hole collapse and mixing of soil and/or ground water with the concrete. It is permissible (and desirable) to vibrate just the top five feet of the final concrete column to assure flow through the rebar cage at the top.

Free-fall placement should not be used in open boreholes in cohesionless soils (e. g., moist or clayey sands that will stand open without slurry or casing) unless it can be shown by constructing trial shafts at the job site that doing so will not cause hole collapse.

48. Prior to concrete placement, has the slurry (both manufactured & natural) been tested in accordance with xxx.38, Slurry?

xxx.38 SLURRY

- **Must sample and test slurry prior to placing concrete**
- **Need two consecutive tests producing acceptable results**
- **Concrete cannot be placed until passing test results achieved**

13-26

<u>FHWA Publication IF-99-025</u>

xxx.38 SLURRY

….Prior to placing concrete in any shaft excavation, the Contractor shall take slurry samples….until two consecutive samples produce acceptable values for density, viscosity, and pH.

When any slurry samples are found to be unacceptable, the Contractor shall take whatever action is necessary to bring the slurry within specification requirements. Concrete shall not be poured until the slurry in the hole is re-sampled and test results produce acceptable values.

49. If required, was casing removed per xxx.36.1, Temporary Casings?

xxx.36.1 TEMPORARY CASINGS

- **Level of fresh concrete shall be a minimum of 5 ft. (1.5 m) above:**

  - hydrostatic water level, or

  -drilling fluid level in annular space behind casing

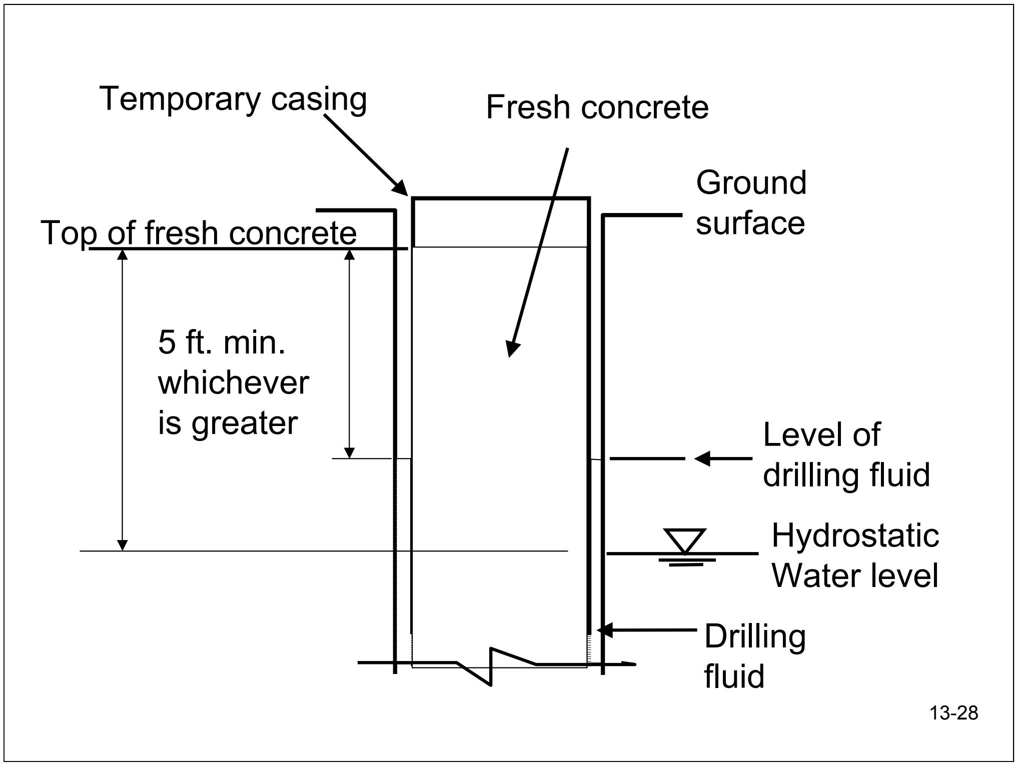
  <u>**whichever is greater**</u>

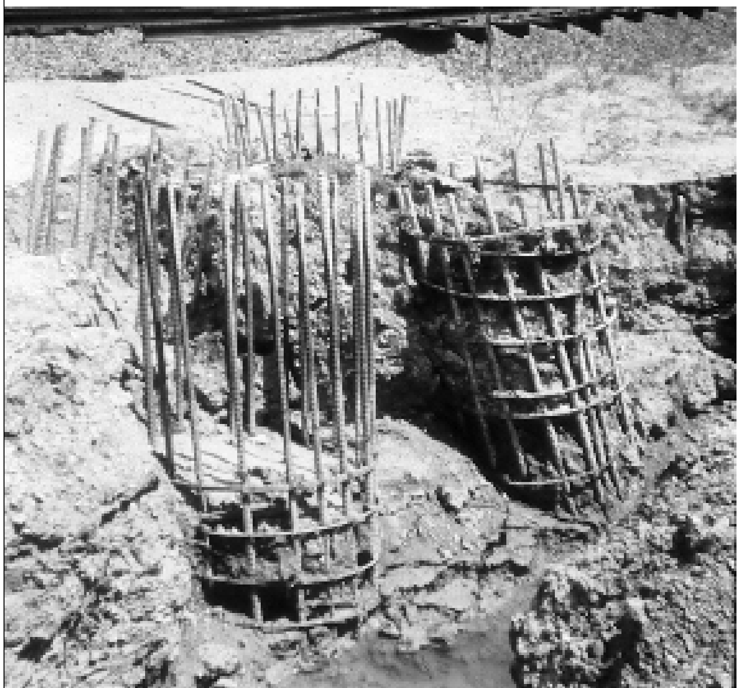
13-27

<u>**FHWA Publication IF-99-025**</u>

xxx.36.1 TEMPORARY CASINGS

…. Before the casing is withdrawn, the level of fresh concrete in the casing shall be a minimum of five feet (1.5 m) above either the hydrostatic water level in the formation or the level of drilling fluid in the annular space behind the casing, whichever is higher. As the casing is withdrawn, care shall be exercised to maintain an adequate level of concrete within the casing so that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete.


Temporary casing
Fresh concrete
Ground surface
Top of fresh concrete
5 ft. min. whichever is greater
Level of drilling fluid
Hydrostatic Water level
Drilling fluid
13-28



Be Alert for Rising Concrete or Cage as Casing is Being Pulled

13-29

This slide illustrates the need to make sure concrete is still fluid when the casing is removed. This concrete had too low a slump when the casing was pulled. That was complicated by the fact that the shafts were installed on a batter, and casings snagged on some of the rebar. The result is a series of rejected shafts. The fix was made by excavating about 15 feet, breaking out the concrete and repouring the top sections of the shafts -- very costly.

50. Was the discharge end of the tremie maintained in the concrete mass with proper concrete head above it (xxx.61, Tremies)?

xxx.61 TREMIES

- **Discharge end of tremie must be immersed a minimum of 5 ft. (1.5 m) in the concrete at all times**
- **Flow of concrete must be continuous**
- **Concrete level in tremie must be above slurry or water level in hole**
- **If tremie breaches, discharging concrete, the shaft is considered defective**

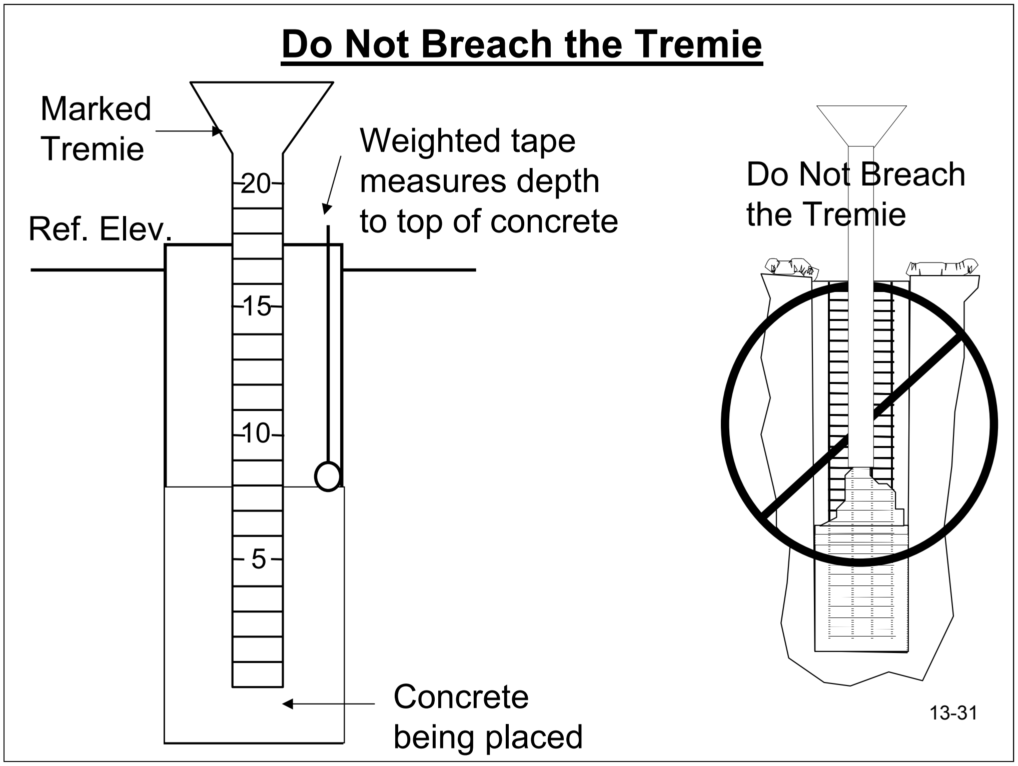
13-30

FHWA Publication IF-99-025

xxx.61 TREMIES

…. The tremie discharge end shall be immersed at least 5 feet (1.5 m) in concrete at all times after starting the flow of concrete. The flow of the concrete shall be continuous. The level of the concrete in the tremie shall be maintained above the level of slurry or water in the borehole at all times to prevent water or slurry intrusion into the shaft concrete.
If at any time during the concrete pour, the tremie line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft shall be considered defective.

It is during the placement of concrete that the Inspector is responsible for recording the amount of concrete per truck, the depth to the top of the concrete following placement of each load, verifying the placement is continuous, and that the tremie doesn't breach.



The tremie is sealed initially and lowered to the bottom of the hole. The tremie tube is then filled with concrete. The tremie is lifted 1.0 to 1.5 feet (300-450 mm) to open the seal and allow the concrete to flow out rapidly. Thereafter, the bottom orifice of the tremie must remain at least 5 feet (1.5 m) below the concrete level in the shaft. Tremie bottom level is monitored from markings on the side of the tremie, while concrete level is determined by using a weighted tape. The individuals making the tremie and concrete level readings are in continuous contact to assure that the tremie bottom remains in proper position. The tremie is lifted as necessary to maintain free flow of concrete. It should not be "yo-yoed" because of the danger of mixing slurry with the concrete. The need to yo-yo the tremie is an indication that the concrete is losing slump too rapidly, that the inside surface of the tremie is too rough or the tremie is too small to allow free flow of the concrete.

51. If free-fall placement (dry shaft only), was concrete placed in accordance with xxx.60, Concrete Placement?

xxx.60 CONCRETE PLACEMENT

- **Free fall placement only permitted in dry holes**
- **Must fall to base of shaft without contacting rebar cage or shaft walls**
- **Drop chutes may be use**

13-32

<u>FHWA Publication IF-99-025</u>

xxx.60 CONCRETE PLACEMENT

…. The free fall placement shall only be permitted in dry holes. Concrete placed by free fall shall fall directly to the base without contacting either the rebar cage or hole sidewall. Drop chutes may be used to direct concrete to the base during free fall placement…

52. Did the placement occur within the time limit specified (xxx.60, Concrete Placement)?

xxx.60 CONCRETE PLACEMENT

- **Placement, from start to finish, shall not exceed 2 hours**
- **Longer placement times may have been approved by the Engineer**

13-33

FHWA Publication IF-99-025

xxx.60 CONCRETE PLACEMENT

…. The elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed 2-hours.

When the mix is designed (or standard mix verified), a slump loss test should be performed, in which the slump is checked every 30 minutes after batching until the concrete takes its initial set. A good rule of thumb is that the concrete should have a slump of four inches (100 mm) four hours after batching. This should give enough time for ordinary delays in delivery, for maneuvering of pumps, casings, etc., and for the placement of the concrete itself, which may take 3 - 4 hours in some large shafts. It is sometimes necessary to use retarders (especially in hot weather) to attain the ideal slump loss relationship.

POSSIBLE PROBLEMS

- ***Horizontal sand lenses in concrete-*** **tremie or pump line pulled out of concrete when concreting under slurry or water.**

- ***Quarter-moon shaped soil intrusion on the side of the shaft-*** **interruption of flow of concrete being pumped or tremied into slurried hole for more than a few minutes; use of telescoping casing where concrete from inner casing spills into the overbreak zone behind outer casing.**

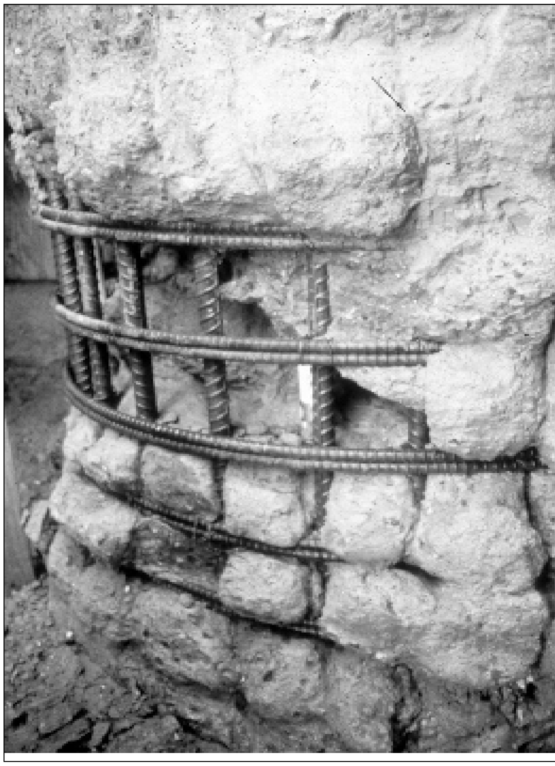
13-34

POSSIBLE PROBLEMS

- ***Voids outside of cage-*** **low concrete slump or reinforcing bars too close together.**

- ***Honeycombing, wash out of fines or water channels in the concrete-*** **concrete placed directly in the water; excessive groundwater head.**

13-35



Structural Defect Produced by Interruption in Concreting

13-36

If concrete delivery is interrupted (in this case for about 1.5 hours), sediment can settle out of the slurry and deposit itself on top of the standing concrete in the hole. Once the pour resumes, the new more fluid concrete flows over the old concrete and traps the sediments against the side of the borehole. This is a very common cause for defective drilled shafts when the wet method is used.

TYPICAL INSPECTOR DUTIES DURING PLACEMENT

- **Record start and finish times for placement**
- **Record concrete quantity per load/truck**
- **Measure and record depth/elevation of top of concrete after each load**
- **Plot concrete volume curve**
- **Verify placement is continuous**
- **Monitor for breaching of tremie**

13-37

<u>LEARNING OBJECTIVE #1</u>
Describe how to verify Checklist Questions 48-55

T or F: Free fall concrete placement is permitted in dry holes, cased holes and wet method holes.

Prior to placing concrete, the Contractor must sample and test the slurry. How many consecutive samples must have acceptable results for the slurry to pass?

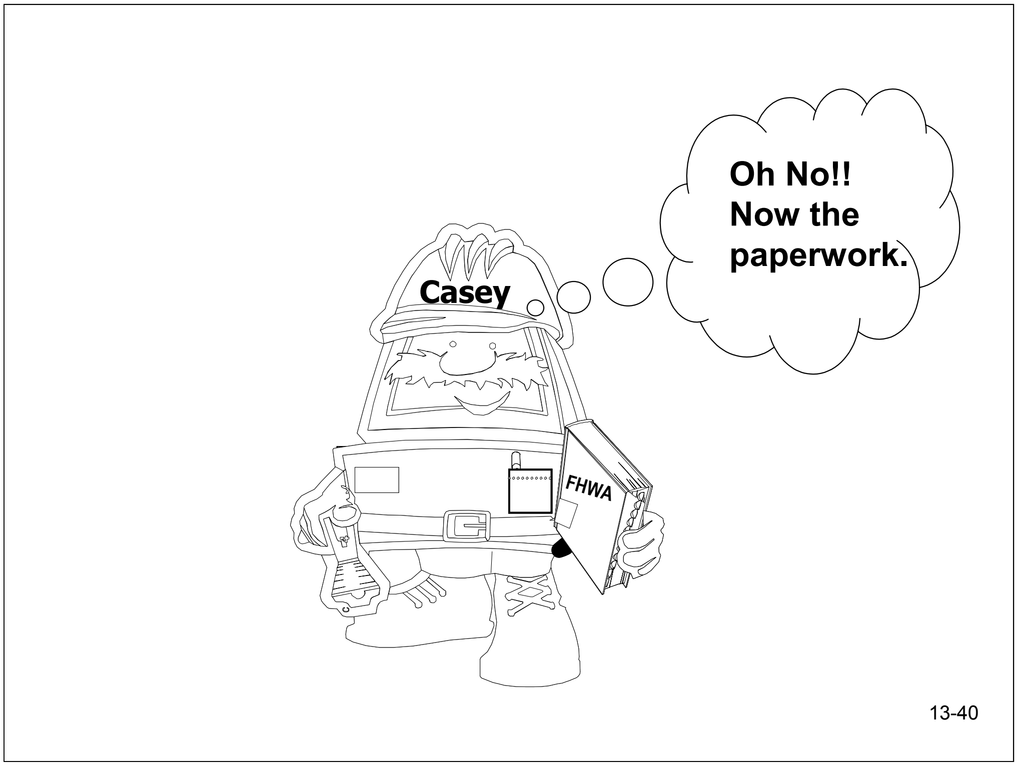
13-38

<u>LEARNING OBJECTIVE #1</u>
Describe how to verify Checklist Questions 48-55

The tremie must be immersed a minimum of ___ feet into the concrete during placement.

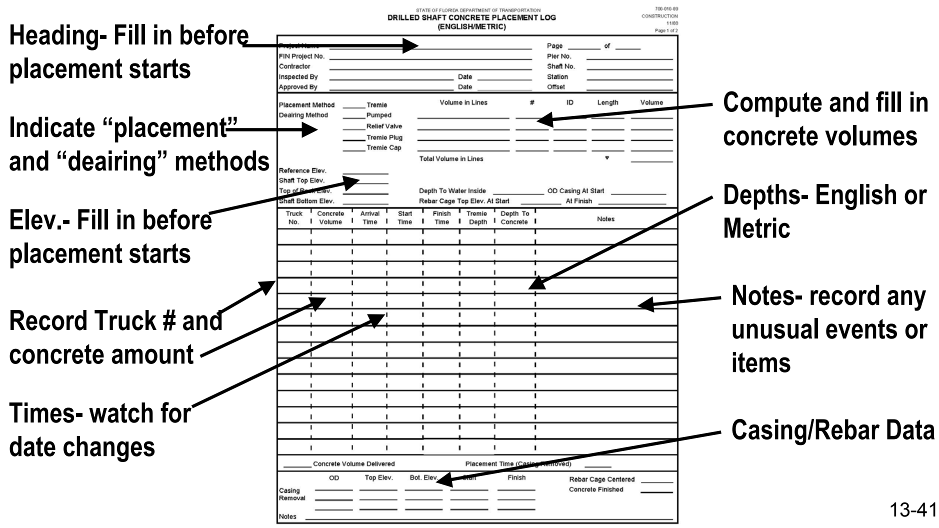
Generally, without approval, the concrete placement must start and finish within a ____ hour period.

13-39


Oh No!!
Now the
paperwork.
Casey
FHWA
13-40

53. Are you filling out the concrete placement and volume forms?

Completing the Concrete Placement Log



13-41

Fill in every blank on the form. If it does not apply, put an "N/A" or a long dash.Use pencil -- but never erase. If you need to change something, strike a single line through the item and insert the correct information above it. If there is insufficient room to make a note, footnote the item and go to the bottom of the page, or use a separate page.

1. Heading : - Fill in <u>before</u> drilling starts.
2. Indicate Correct "Placement" and "Deairing" method
3. Compute and fill in Concrete Volumes: $V = \frac{\pi d^2 \times L}{4}$
4. Fill in as much as possible prior to pour.
5. Record Truck number and amount of concrete- Coordinate with the Inspector who is testing the concrete.
6. Time: May be military or standard clock. Be consistent and correct. Watch for date changes on late night pours.
7. Depths: Tremie embedment may be measured by markings on the tremie.
   Depth to concrete may be measured by weighted tape
8. Notes: Record any unusual events or items.
9. Casing/Rebar Data: The rebar cage fabrication will normally be performed off-site (there may be some instances where you will fill this function, such as high mast lighting). Observe the lifting to make sure deformation or damage doesn't occur. Check that the correct cage is being used. Check reinforcing steel diagram against the actual cage to be sure cage is correct. When the cage is being placed observe the spacing to ensure the cage is set to the proper elevation.

SAMPLE

DRILLED SHAFT CONCRETE PLACEMENT LOG
(ENGLISH/METRIC)

CONSTRUCTION
11/00
Page 1 of 2

Project Name ____________________ Page ______ of ______
FIN Project No. ____________________ Pier No. __________
Contractor ____________________ Shaft No. __________
Inspected By ______________ Date ________ Station __________
Approved By ______________ Date ________ Offset __________

Placement Method ______ Tremie
Deairing Method ______ Pumped
______ Relief Valve
______ Tremie Plug
______ Tremie Cap

Volume in Lines	#	ID	Length	Volume
Total Volume in Lines			▿	

Reference Elev. __________
Shaft Top Elev. __________
Top of Rock Elev. __________
Shaft Bottom Elev. __________

Depth To Water Inside __________ OD Casing At Start __________
Rebar Cage Top Elev. At Start __________ At Finish __________

Truck No.	Concrete Volume	Arrival Time	Start Time	Finish Time	Tremie Depth	Depth To Concrete	Notes

________ Concrete Volume Delivered Placement Time (Casing Removed) _______

	OD	Top Elev.	Bot. Elev.	Start	Finish
Casing Removal					

Rebar Cage Centered ________
Concrete Finished ________

Notes ____________________

Completing the Concrete Volumes on Concrete Placement Log

Truck No.	Concrete Volume	Arrival Time	Start Time	Finish Time	Tremie Depth	Depth To Concrete	Notes
1	9 cyd	0700	0710	0725	70 ft	58 ft	
2	9 cyd	0712	0727	0745	70 ft	46 ft	
3	9 cyd	0720	0748	0810	62 ft	34 ft	
4	9 cyd	0800	0815	0830	62 ft	22 ft	
5	9 cyd	0810	0832	0845	50 ft	7.5 ft	
6	7 cyd	0830	0847	0859	50 ft	0.0 ft	Est. waste= 3.0 cyds

52 cyd Concrete Volume Delivered

Placement Time (Casing Removed) 2hr. 15 min.

13-43

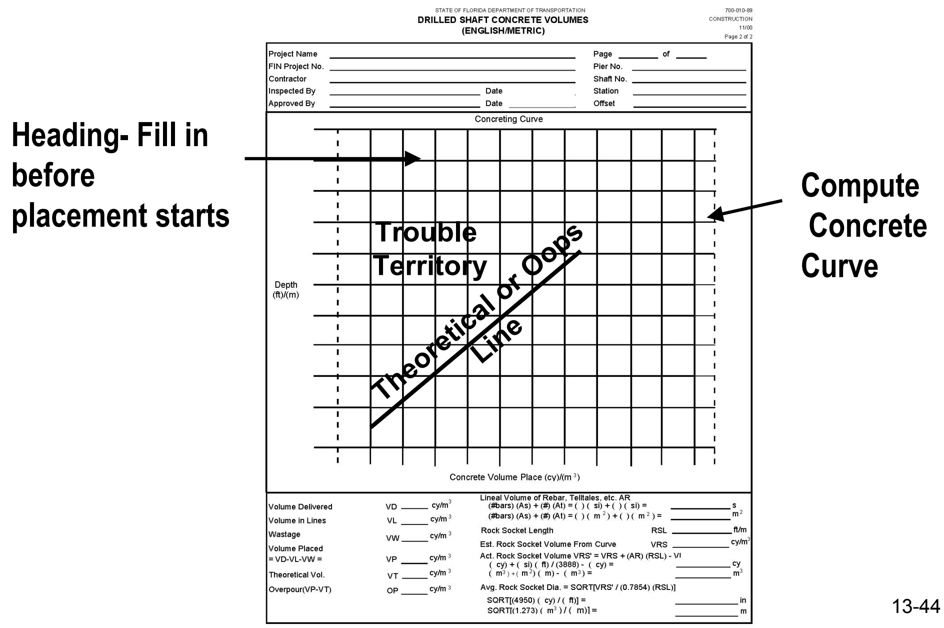
During the placement, as discussed earlier, it is important to constantly check the depth of the tremie and concrete to ensure the bottom of the tremie stays submerged 5 feet into the concrete.

As illustrated above, as each truck arrives and pours, the load and times must be recorded, along with the previously discussed depths.

On the last truck, even with the overpour (should always overpour until fresh concrete is coming from the hole) only 7 yds were delivered.

An estimate of the waste (overpour) should be noted, as all 7 yds did not go into the shaft.

Completing the Concrete Volumes Form



13-44

Fill in every blank on the form. If it does not apply, put an “N/A” or a long dash.
Use pencil -- but never erase. If you need to change something, strike a single line through the item and insert the correct information above it. If there is insufficient room to make a note, footnote the item and go to the bottom of the page, or use a separate page.

1. Heading: - Fill in <u>before</u> concreting starts.
   - Be sure to print your name & the date
   - The Geotechnical Engineer will sign approval line.
   - Record from Key Sheet (station & offset not applicable)

2. Concrete curve: - compute theoretical volume based on shaft size:

   $V = A\,L$ where $A = \pi r^2$
   - locate points based on known cubic yards of concrete placed at measured “bottom” depth
   - must be plotted during concrete placement

Note: Plotted line should closely parallel theoretical -
There is a problem if:
**** a point plots way above or below the OS! line***
**** there is a significant rise or fall in an otherwise straight line***

SAMPLE

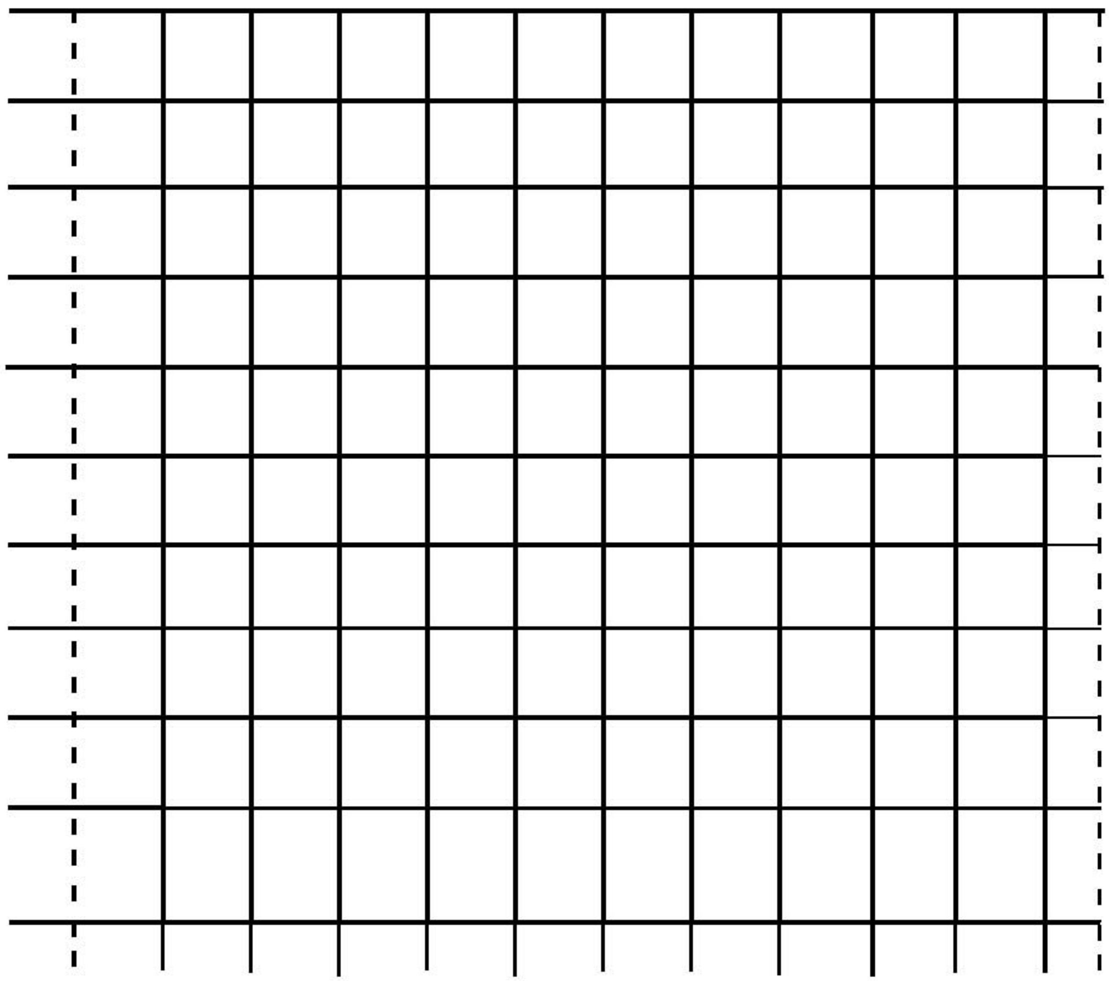
DRILLED SHAFT CONCRETE VOLUMES
(ENGLISH/METRIC)

CONSTRUCTION
11/00
Page 2 of 2

Project Name	______________________________	Page ______ of ______	
FIN Project No.	______________________________	Pier No.	______________
Contractor	______________________________	Shaft No.	______________
Inspected By	______________ Date ______________	Station	______________
Approved By	______________ Date ______________	Offset	______________

Concreting Curve

Depth (ft)/(m)



Concrete Volume Place (cy)/(m^3)

Volume Delivered	VD ______	cy/m^3
Volume in Lines	VL ______	cy/m^3
Wastage	VW ______	cy/m^3
Volume Placed = VD-VL-VW =	VP ______	cy/m^3
Theoretical Vol.	VT ______	cy/m^3
Overpour(VP-VT)	OP ______	cy/m^3

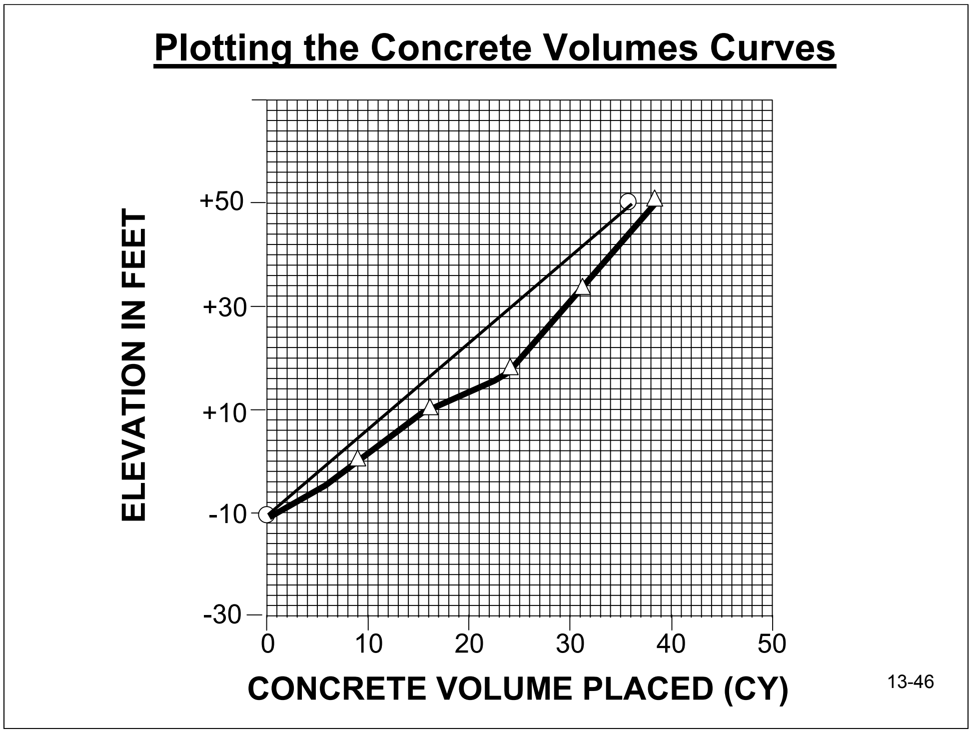
Lineal Volume of Rebar, Telltales, etc. AR
(#bars) (As) + (#) (At) = ( ) (si) + ( ) (si) = ______________ s
(#bars) (As) + (#) (At) = ( ) (m^2) + ( ) (m^2) = ______________ m^2

Rock Socket Length RSL ______________ ft/m

Est. Rock Socket Volume From Curve VRS ______________ cy/m^3

Act. Rock Socket Volume VRS' = VRS + (AR) (RSL) - VI
(cy) + (si) (ft) / (3888) - (cy) = ______________ cy
(m^3) + (m^2) (m) - (m^3) = ______________ m^3

Avg. Rock Socket Dia. = SQRT[VRS' / (0.7854) (RSL)]
SQRT[(4950) (cy) / (ft)] = ______________ in
SQRT[(1.273) (m^3) / (m)] = ______________ m



To complete the concrete volumes curve follow these steps.

1. Determine the theoretical volume of the hole. Plot that. Should be a straight line, as illustrated above by the solid line. In this example, the bottom of the shaft was at elevation –10.00 ft, with a finished elevation of +50.00 ft. and a theoretical concrete volume of 36 yd^3.
2. As each load is placed in the shaft, determine the accumulated volume and the elevation at the top of the concrete and plot that point for each load. The dashed line shows a example plot.

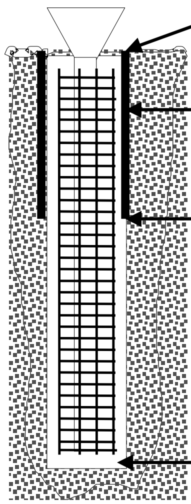
DETERMINING CONCRETE VOLUMES

To perform your responsibilities and complete the Concrete Placement and Volume Form, you need to know how to:

- Calculate the theoretical volume of the shaft
- Determine the depth to top of concrete in the shaft
- Plot the actual concrete volume versus the theoretical volume
- Recognize problems based upon the concrete volume plots

13-47

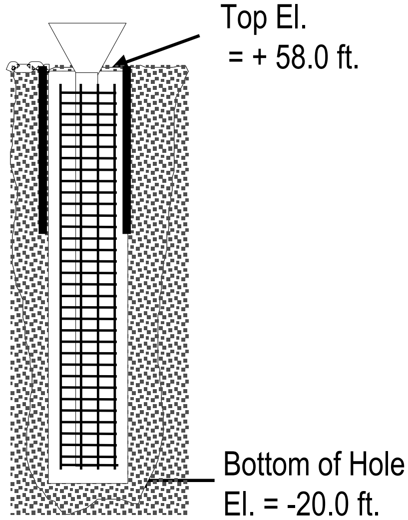
CONCRETE VOLUMES
PRACTICE PROBLEM #1



1. Calculate the theoretical volume of the hole

13-48

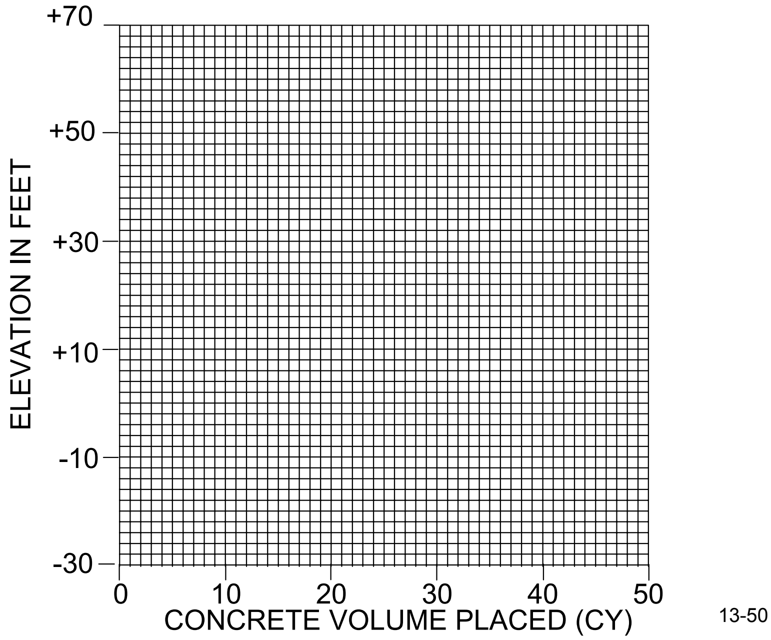
CONCRETE VOLUMES
PRACTICE PROBLEM #1 (CONT.)

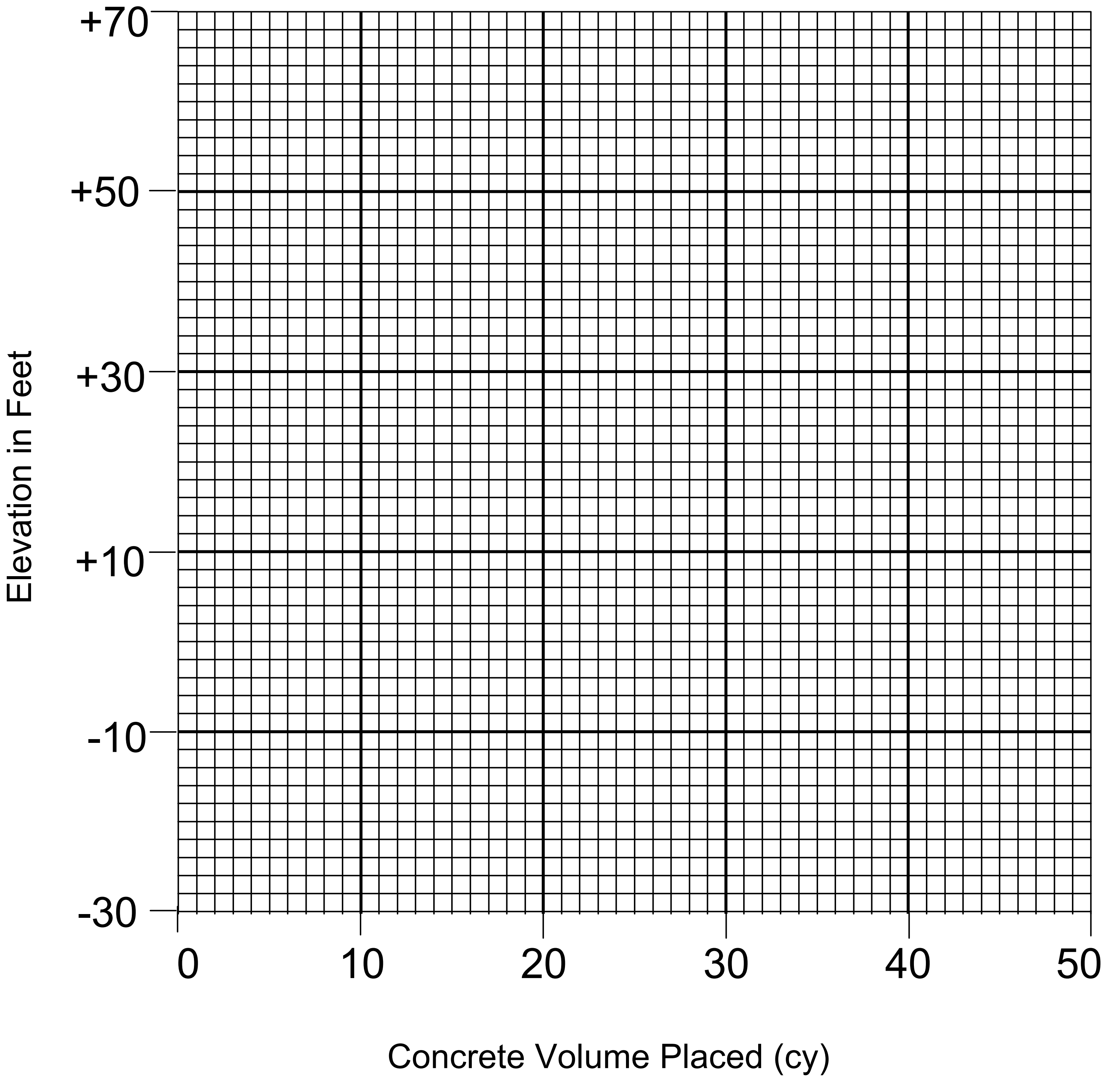


2. Concrete volume following each truck

13-49

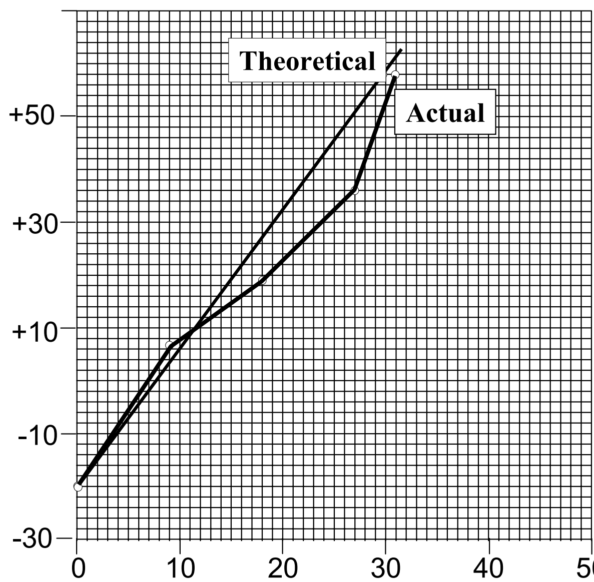
Plot the Concrete Volume Curves for the previous slide




Elevation in Feet
+70
+50
+30
+10
-10
-30
0
10
20
30
40
50
Concrete Volume Placed (cy)

Concrete Curve #1

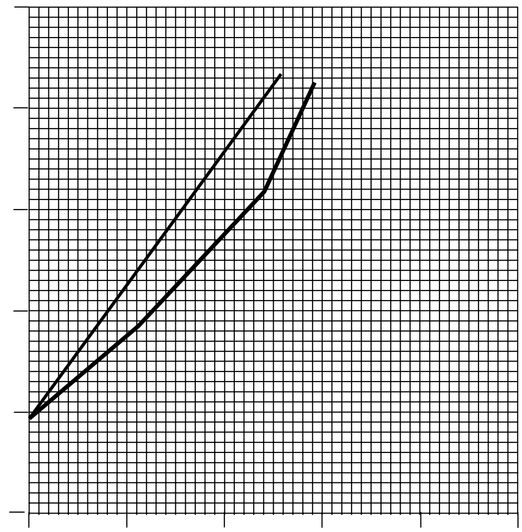
Are there any problems with this curve?



13-52

Concrete Curve #2

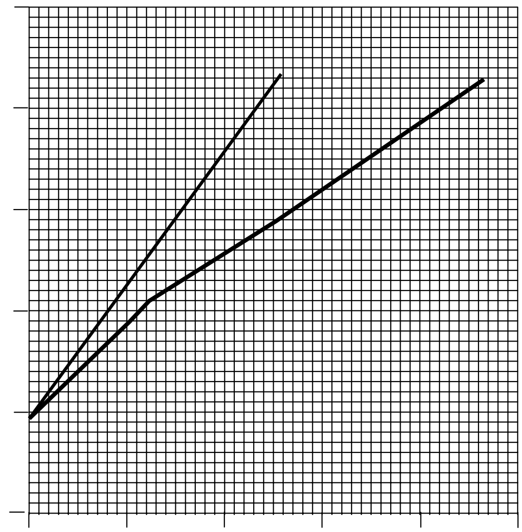
Are there any problems with this curve?



13-53

Concrete Curve #3

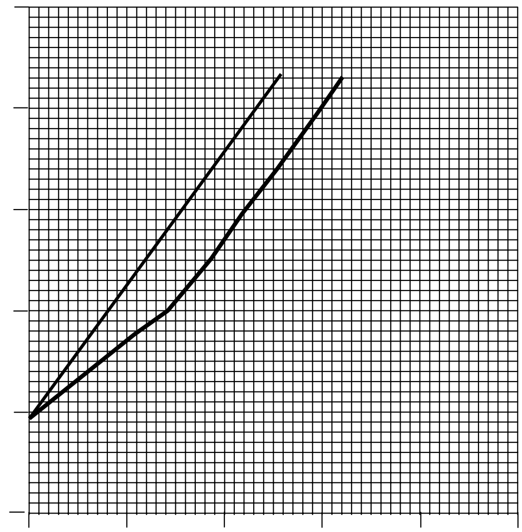
Are there any problems with this curve?



13-54

Concrete Curve #4

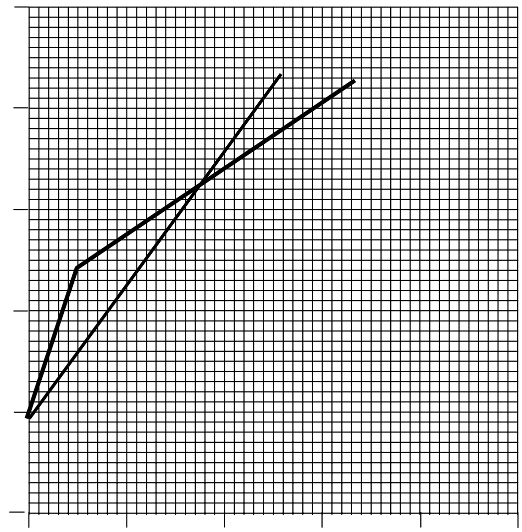
Are there any problems with this curve?



13-55

Concrete Curve #5

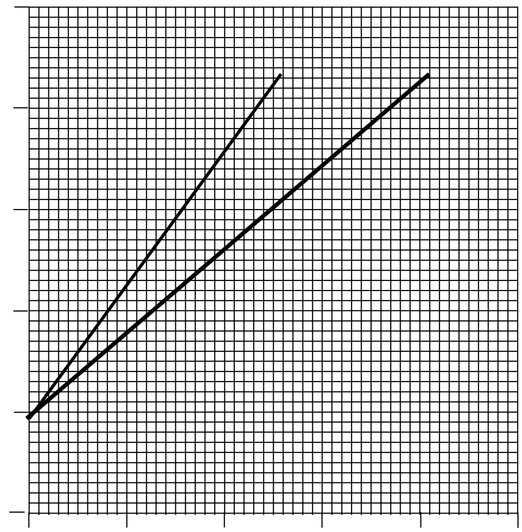
Are there any problems with this curve?



13-56

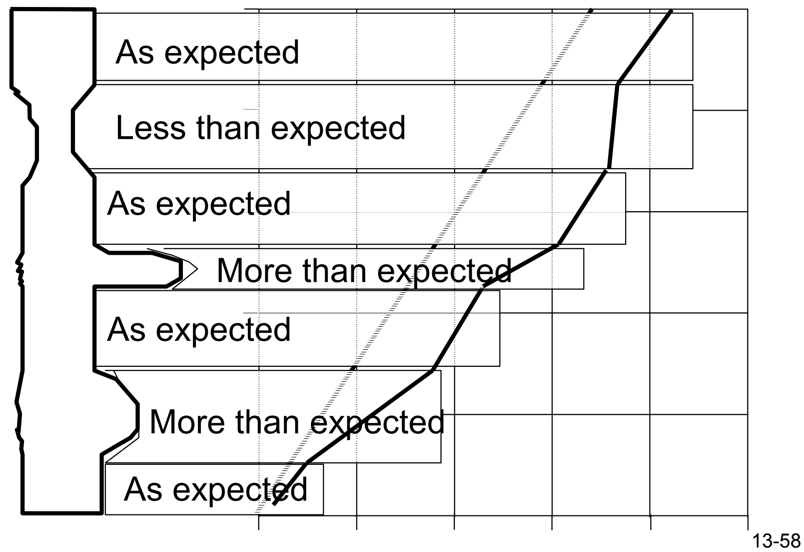
Concrete Curve #6

Are there any problems with this curve?



13-57

Possible Causes of Curve Irregularities



This is an illustration to show how various diameter variations will affect the shape of the plotted concrete curve. Irregularities of this magnitude in one shaft are not common, but in some areas of the country, seams or voids in the formations can take rather large volumes of concrete. The slope of any particular “leg” of the plotted curve relative to the slope of the theoretical curve is what is most indicative of a problem zone.

54. When placing concrete, did the Contractor overflow the shaft until good concrete flowed?

xxx.60 CONCRETE PLACEMENT

- **Placement continuous from bottom to top**
- **Placement stops when good quality concrete is evident (overflow)**

13-59

<u>FHWA Publication IF-99-025</u>

xxx.60 CONCRETE PLACEMENT

…. Concrete placement shall be continuous from the bottom to the top elevation of the shaft. Concrete placement shall continue after the shaft excavation is filled until good quality concrete is evident at the top of shaft.

55. Were concrete acceptance tests performed as required?

Typical Sampling and testing to be performed:

- **Slump**
- **Air Content**
- **Temperature**
- **Strength Test Specimens**

13-60

Typical Sampling and testing to be performed:

• Slump

• Air Content

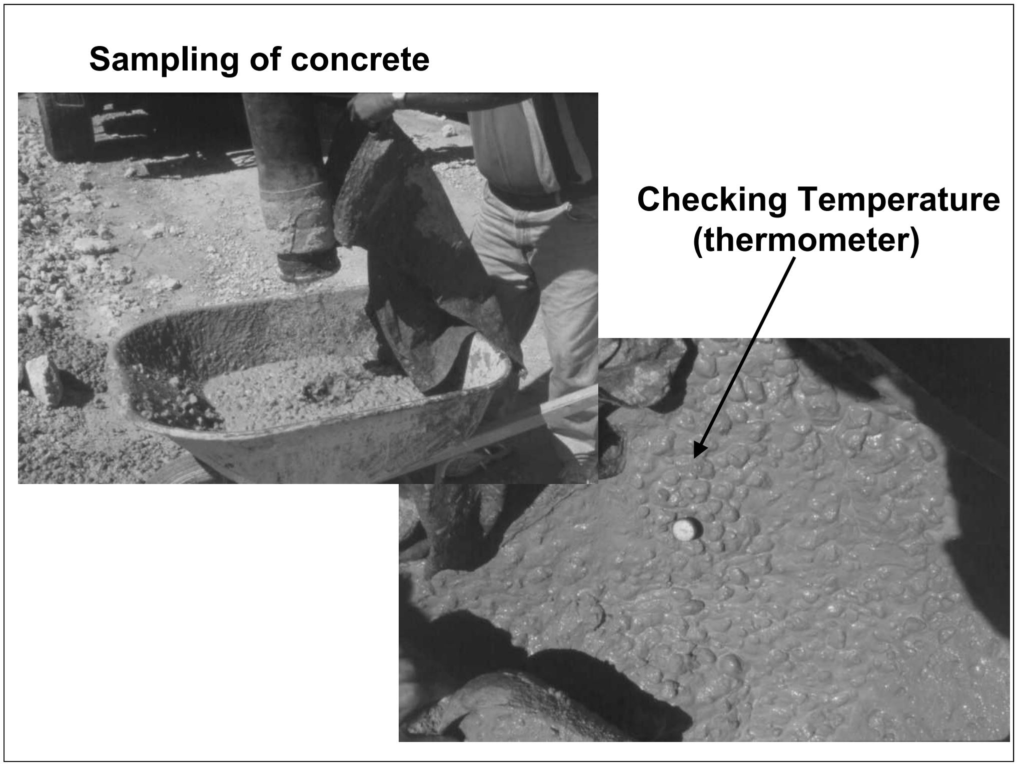
• Temperature

These may or may not be required on every load

• Strength Test Specimens

Typically at least one set per day or specified quantity.

13-61



Sampling Freshly Mixed Concrete (AASHTO T 141-97) (ASTM C 172-90)- This is the method of sampling freshly mixed concrete delivered to the project .

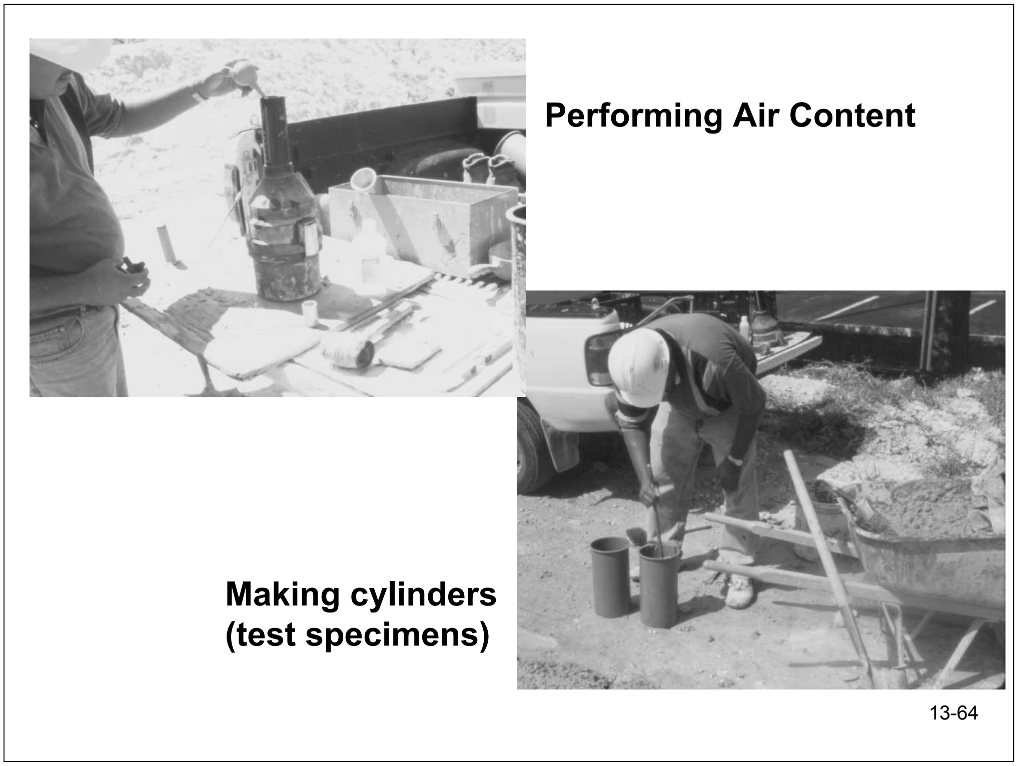
Temperature- (ASTM C 1064)- This test provides a means of measuring the temperature of freshly mixed concrete. It is used to verify conformance to a specified requirement for temperature of concrete.

Preparing to “slump” concrete

Measuring the slump

13-63

Slump of Hydraulic Cement Concrete-(AASHTO T 119-97) (ASTM C 143-90a)- In this test a sample of freshly mixed concrete is placed and compacted by rodding in a 12” high mold, shaped as a frustum of a cone. The mold is raised, and the concrete allowed to subside. The distance between the original and displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.



Air Content of Freshly Mixed Concrete by the Pressure Method- (AASHTO T 152-97) (ASTM C 231-91b)- This is the method used to determine the air content of freshly mixed concrete. In this test, air content is determined by observing the change in volume with a change in pressure of concrete placed in an air meter.

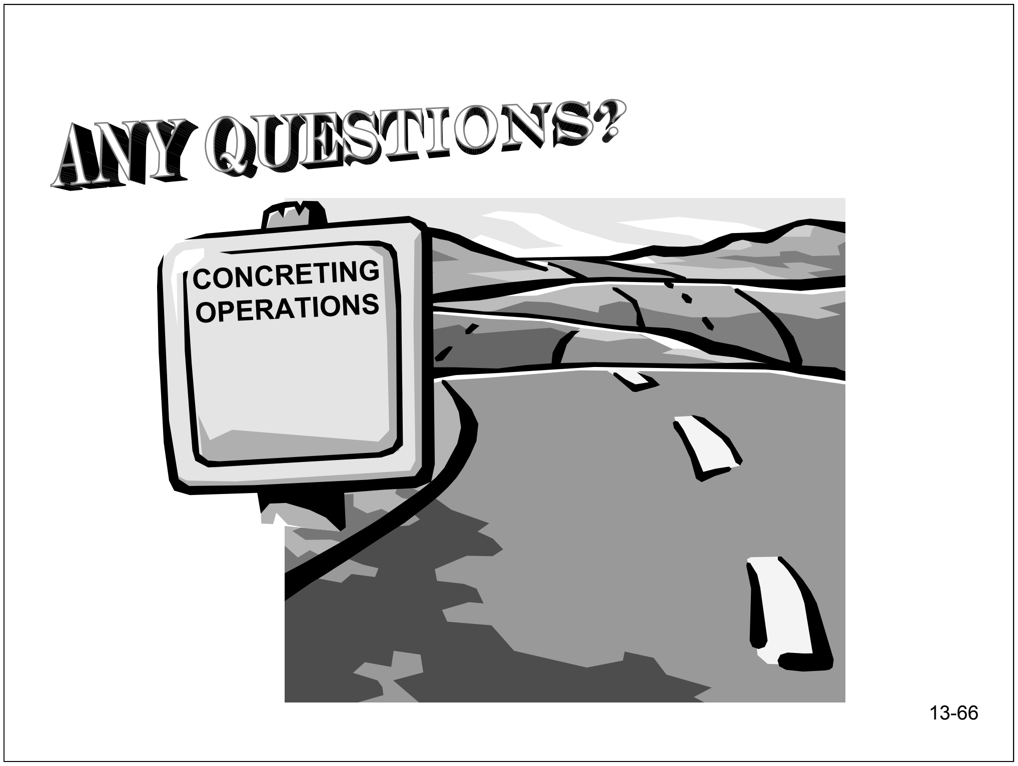
Content of Freshly Mixed Concrete by the Volumetric Method- (AASHTO T 196-96) (ASTM C 173-94a)- This test determines the air content of concrete based upon measurement of the air contained in the mortar fraction of the concrete.

Making and Curing Concrete Test Specimens in the Field- (AASHTO T 23-97) (ASTM C 31-95)- This covers the making of the cylinders of the sampled concrete. Typically a set of three cylinders are made by placing the concrete in three equal layers of concrete in a 12” by 6” mold, rodding each layer 25 times until full.

LEARNING OBJECTIVES

- Describe how to verify Checklist Questions 48-55
- Describe typical slump requirements for Drilled Shaft concrete
- Utilize the Concrete Placement Log inspection form to determine theoretical concrete volumes and placed concrete volume curves

13-65


ANY QUESTIONS?
CONCRETING
OPERATIONS
13-66